

ADAPTIVE MODIFICATION OF SURFACE PROPERTIES TO ALTER  
THE PERCEPTION OF ITS UNDERLYING STRUCTURE

Specification

Field of the Invention

Adaptively modifying properties of a viewed surface to  
change the perception of its underlying structure.

Background of the Invention

Many of the definitive characteristics of a structure are  
perceived by a viewer or investigative system by properties of  
its surface. While the surface characteristics may be entirely  
different from characteristics of the underlying structure, still  
they at least suggest to the observer significant information  
about the structure itself.

For example, a coat of paint on the chassis of a vehicle  
says something about the shape and color of the coat of paint on  
the vehicle, but it says nothing about the metal skin on which it  
is laid, except for its outer shape and color assuming that the  
paint is a uniform layer. Similarly it says nothing about an  
engine or anything else inside of it or inside an overlaying or  
shrouding skin. Thus, the characteristics of a surface which is  
directly viewed by the observer convey all of the information  
available to the observer. Changing these characteristics can  
change the observer's perception of the structure itself.

For example, in visible light, color patterns in a coat of

EL98763824901 Date of Deposit 10/25/03  
"Express Mail" mail label  
I hereby certify that this paper or fee is being deposited with the United States Postal Service "Express Mail Post Office to  
Addressee" service under 37 CFR 1.10 on the date indicated above and is addressed to the Commissioner for Patents, P. O. Box 1450,  
Alexandria, VA 22313-1450  
Donald D. Hon  
Reg. No. 18,255

1 paint may be of considerable interest. National emblems,  
2 cautionary displays, distracting or misleading images, and colors  
3 that do or do not contrast with the background are examples.  
4 Some colors may be intended to be glaringly obvious, while others  
5 are preferred to fade into the background. The art of color  
6 camouflage exemplifies one field of presenting a colored surface  
7 that is hopefully hidden in plain sight.

8 The above relates to reactions to visible light which light  
9 is emitted by, or which is reflected from the surface. This is  
10 only one example of means to perceive a structure. Other means  
11 which are pertinent to this invention are responses to  
12 frequencies outside of the visible spectrum, for example infrared  
13 and radar frequencies. For these, observation devices vary from  
14 reception of frequencies emitted or which are reflected by the  
15 surface itself, namely its infrared emission, or received (or  
16 modified) reflection of radar frequencies originated by the  
17 observing device which are reflected by the surface.

18 It is an object of this invention adaptively to change  
19 significant properties of the surface of a structure, by altering  
20 the emissive properties of the surface itself, or by altering its  
21 reflective properties. In both of these circumstances an  
22 observing device or person will be convinced to perceive  
23 pertinent properties that are not necessarily those of the  
24 underlying structure.

1       Reduced to absurdity, a structure may be camouflaged by  
2 repainting it, or by painting over indicia, for example. But  
3 then this arrangement remains until a next coat of paint is  
4 applied. Desert vehicles are painted once. If they are sent to  
5 the Arctic, they may be painted another color. But when they are  
6 in one place, their perceived color pattern is established and  
7 does not change.

8       In contrast, this invention proposes to alter surface  
9 properties literally on demand, between at least two different  
10 conditions. In this specification, the "perceived surface" is  
11 the interface with the atmosphere which is sensed by an observer.  
12 Its properties are determined by its immediate substrate. For  
13 example, the perceived surface of a coat of paint possesses  
14 properties determined by its substrate paint. A coating that  
15 does not alter the characteristics being observed is not regarded  
16 as the perceived surface for purposes of this invention.

17       This invention utilizes the effect of temperature of the  
18 perceived surface to alter the observed characteristics. For  
19 adaptive purposes, if temperature is the sensed property, the  
20 alternating property is the temperature itself. If color or some  
21 other reflected observable property is to be sensed, then a  
22 temperature-responsive substance is used for the exposed surface,  
23 with a substrate whose temperature can be changed. Of course,  
24 the surface may itself be the boundary of a substrate of the same

1 material, for example a coat of paint. Thermochromic films or  
2 layers for change of colors, and embedded radar absorbing  
3 particles whose size changes with temperature to vary reflection  
4 or adsorption of radar frequencies are examples.

5 The change of temperature is achieved by the use of the  
6 well-known Peltier effect, in which a lower temperature is  
7 created on one side of a semi-conducting array or layer, and an  
8 elevated temperature on the opposite side. This essentially is  
9 the transfer of caloric heat to or from the first surface,  
10 (usually the exposed surface) to an underlying substrate or  
11 structure. The temperature of the exposed surface can thereby be  
12 changed, either increased or decreased, by current applied to the  
13 device, and the direction of the effect. To increase the effect,  
14 one merely increases the current density. Thus, by the mere  
15 exertion of an electrical current, the temperature, and with it  
16 the perception of a surface, can adaptively be adjusted and  
17 changed. Such devices are frequently used as "thermoelectric  
18 coolers" (TEC).

19 With the change in temperature of the exposed surface, its  
20 visible or emission properties can be changed, resulting in  
21 confusion of the observer.

## 22 Brief Description of the Invention

23 This invention utilizes the Peltier effect to control the  
24 temperature of a perceived surface. The controlled temperature

1 is determined by the intensity and direction of the electrical  
2 current applied to the Peltier device.

3 According to this invention the Peltier device is applied as  
4 a surface on or spaced from an underlying structure or substrate  
5 that is shielded from direct observation by the Peltier device  
6 itself.

7 The device itself may be the directly observed surface or it  
8 may carry on it or have applied to it a cover such as paint which  
9 will share the controlled temperature. This cover may itself  
10 have thermochromic properties that are specifically visually  
11 observed, or radar-frequency reflective or absorptive properties  
12 that are specifically reflected or absorbed, the reflection being  
13 the observed property.

14 The perceived surface need not itself be a contiguous part  
15 of the underlying structure. For example it might be  
16 sufficiently spaced from the underlying structure (such as a jet  
17 engine tail pipe), that its own surface temperature is not unduly  
18 associated with the tailpipe temperature, but it is seen by the  
19 observer (for example by a heat-seeking missile) as the structure  
20 itself. Of course it must be suitably spaced from, or suitably  
21 insulated from, such hot gases or surfaces that might melt or  
22 otherwise hamper the Peltier device.

### 23 Brief Description of the Drawings

24 Fig. 1 is a fragmentary cross-section of a Peltier device

1 installed according to this invention;

2 Fig. 2 is a plan view showing a plurality of devices  
3 according to Fig. 1 installed as a group;

4 Figs. 3 and 4 are fragmentary conceptual views showing two  
5 observed conditions;

6 Fig. 5 is a schematic side view, partly in cross section,  
7 showing a use for this invention;

8 Fig. 6 is a view similar to Fig. 5 showing another use for  
9 this invention;

10 Fig. 7 is an axial cross-section of another embodiment of  
11 this invention;

12 Fig. 8 is a cross-section taken at line 8-8 in Fig. 7; and

13 Fig. 9 is a circuit drawing for the control of this  
14 invention.

15 Detailed Description of the Drawings

16 As an example of the intended effect of this invention Figs.  
17 3 and 4 show two different colorations on a surface 21. Surface  
18 21 includes a patterned area 22 and a background area 23. At  
19 normal temperatures, for example atmospheric temperature between  
20 perhaps 70-110 degrees, the surface color, of areas 22 and 23  
21 will be the same. A visual observer will perceive the entire  
22 surface as a single-colored continuum. The outline 24 of  
23 patterned area 22 is shown schematically. It is not a visible  
24 line.

1        When this invention is utilized and the patterned area 22 is  
2 thermochromic, this area became visible in some color different  
3 from the background area 23. A cross thereby became visible,  
4 while the color of background area 23 remained unchanged.

5        This is an example of a visible camouflage. It is equally  
6 possible for the cross to be visible at atmospheric temperature,  
7 but to disappear when heated or chilled to change the temperature  
8 of the viewed surface. Persons skilled in camouflage will  
9 readily recognize the advantages this will provide. Entire  
10 vehicles can change color or color patterns to agree with their  
11 surroundings, for example.

12        The purpose of Figs. 3 and 4 is to illustrate the use of  
13 this invention to modify the perception of a surface locally, or  
14 over broad surfaces. It is also useful as a shield to conceal or  
15 confuse something inside it.

16        For example, Fig. 5 schematically shows a jet engine tail  
17 pipe 30 which is notoriously hot, and is an identifiable target  
18 for heat seeking missiles. The missiles seek the infra-red  
19 source, namely the hot tail pipe. Fig. 5 also shows a shield 31  
20 according to this invention with a perceived surface 32 equipped  
21 with this invention as will be described.

22        Of course this shield cannot be directly applied to the hot  
23 tail pipe. Instead it will be spaced from it by a spacing 33  
24 which insulates it from heat damage. If desired, insulation

1 material (not shown) can be placed between them, instead of  
2 merely an air gap.

3 The mode of employing this invention is schematically shown  
4 in Fig. 2. This illustrates a region 45 in which a group of  
5 Peltier devices 46, 47, 48, 49 are planted or applied. These are  
6 shown to be rectangular although they could instead have any  
7 desired contour. Also they are illustrated as planar bodies,  
8 although they can be curved or otherwise configured.

9 While they are shown spaced apart, generally they will be  
10 quite close to one another. All will have circuit connections  
11 connecting to a control yet to be described. It will be observed  
12 that these devices may be separately controlled, individually or  
13 in groups, to provide for various surface appearances. For  
14 example, some areas may need to be colder than others, especially  
15 when a coating might have more than one pertinent color which can  
16 be selected by a respective temperature.

17 Fig. 1 is a fragmentary cross-section of a Peltier device 60  
18 (sometimes herein referred to as a thermoelectric cooler - TEC).  
19 It is installed on the surface 61 of a substrate 62 whose  
20 perception is to be changed. A layer 63 of electrical insulation  
21 is placed on surface 61.

22 A thermoelectric semiconductor 65 is placed between two  
23 electrical conductors 66, 67, which are arranged as not to contact  
24 each other, because they become heat sinks as well as the supply



1 of electrical current to the thermoelectric semiconductor.  
2  
3  
4  
5  
6  
7  
8  
9  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24

A layer 70 of electrical insulation overlays this arrangement. The material whose temperature is to be controlled may be a layer 72 of thermochromic paint whose color is to be controlled. Alternatively, an interim thermally conductive layer (not shown) of material protective of the Peltier device may be placed between the paint and the insulation.

A thin protective layer 73 may be laid on the paint or other responsive surface is desired.

Fig. 5 is directed to presenting a different emitted property such as color or temperature as viewed by a viewing device 80 through a lens 81 or collector.

Fig. 6 is directed to presenting a different reflective property such as a changed frequency or absorbed frequency. A thermally responsive layer 85 is applied to a TEC layer 86. It receives energy from a source 87 such as a radar transmitter, and reflects energy to a receiver 88. The properties of the received beam 89 and the reflected beam 90 are different, having been modified by the thermally-responsive layer. The composition of thermally responsive layer 85 will be described in more detail below.

The TEC may be formed in shapes other than flat. They may be curved to conform to the shape of a substrate, or even, as shown in Figs. 7 and 8 be made in the form of circular rods,

1 wires, or as flexible threads or strings which can be woven into  
2 fabrics.

3 A typical example is shown in Fig. 7, showing a wire having  
4 a central conductor 91, a surrounding thermoelectric  
5 semiconductor 92, an electrical insulator 93, and a surrounding  
6 thermochromic layer 94. The conductor acts as a heat sink. The  
7 outer layer of the thermoelectric semiconductor can change the  
8 temperature of the thermochromic layer.

9 Fig. 9 shows a useful example of control circuit to vary the  
10 temperature of a group of thermoelectric cells 100,101,102.  
11 These cells are connected in parallel, the direction of heat flow  
12 and thereby the temperature of the surface being observed.

13 With reference to the drawings, the following is a  
14 description of the operation of the circuit.

15 Turning on power switch S1 energizes the timer consisting  
16 of a 555IC operating as a monostable "one shot" The time in  
17 seconds is set by RI and CI. RI is adjustable from the left side  
18 of box. Clockwise (CW) turning of adjustment increases the time.  
19 Time can be set between approximately 0.5 seconds to 10 seconds.  
20 Selecting S3 from OFF to HOT or COLD sets the painted surface  
21 temperature choice. The timer is triggered by momentarily  
22 pushing S2 operating K1 supplying power to the TECs through K1  
23 contacts, which open at the end of the set time. S3 can be  
24 switched in the opposite direction and a new cycle initiated if

1 desired. Frequency of cycles is limited by the heatsink  
2 capacity. Turning S3 and S1 to OFF removes all power. The  
3 battery can be recharged externally through J1 mounted on the  
4 right side of box. The battery is a 12V battery.

5 Conventional Peltier device materials can be used, but in  
6 many situations they would be excessively rigid or thick. An  
7 alternative construction is proposed by the invention herein,  
8 namely structures formed by thin film manufacturing techniques.  
9 Such film structures can enhance flexibility, efficiency,  
10 temperature ranges, and quick response times.

11 Conventional thermoelectric devices normally utilize  
12 materials such as bismuth telluride with "p" and "n" type  
13 semiconductor junctions. Silicon and dopants are included in the  
14 basic materials to provide or enhance the semiconductor  
15 properties. In addition, conventional technology utilizes  
16 brittle ceramic insulating elements and requires inherently  
17 thick, rigid construction.

18 A preferred embodiment for the present invention in thin  
19 film planar or fiber form would be to utilize doped silicon  
20 carbide as the semiconductor material. Dopants such as bismuth  
21 telluride, gallium arsenide, or gallium compounds enhance the "p"  
22 and "n" characteristics. Silicon carbide is a majority carrier  
23 (also called a wide bandgap semiconductor) which is noted for low  
24 leakage current and relatively high temperature stability. Thus

1 high current densities can be supported (compared to silicon).  
2 The thin film silicon carbide Peltier effect layer can best  
3 be fabricated by plasma arc deposition essentially the same as  
4 that described in Snaper U.S. Patent No. 5,254,235 which is made  
5 in part hereof by reference for its disclosure of this technique.  
6 The apparatus and method outlined therein would be identical.  
7 Only the deposition materials would differ. Other suitable  
8 fabrication methods would include chemical vapor disposition,  
9 sputtering, and vacuum deposition.

10 Compared to silicon or gross bismuth telluride, silicon  
11 carbide offers up to four times better thermal conductivity,  
12 higher blocking voltage range, and predictable area specific  
13 differential resistance. Due to these characteristics, silicon  
14 carbide thermoelectric junctions can be made thinner without  
15 voltage breakdown limitations (compared to silicon) and can also  
16 be effectively paralleled. Silicon carbide also has a practical  
17 switching frequency of up to 500KHz which is desirable should  
18 rapid response be desired for some applications.

19 Radar masking can also be accomplished by the incorporation  
20 of radar absorbing particles or dipoles added to the  
21 thermochromic paint layer or to the active film. For example  
22 very small fibers or particles of materials such as carbon,  
23 carbon nanotubes, or conductive metals such as copper or silver  
24 in which the particle length is sized to act as a dipole absorber

1 for the gen ral frequency utilized in radar detection or ranging.  
2 These materials by a process of absorption, adsorption, multiple  
3 internal reflection tend to disperse radar impingement and reduce  
4 the amount of direct reflection back to the radar source thus  
5 shielding the target from detection to a great extent.

6 Another unique feature possible is that by controlling the  
7 temperature of the thermochromic film containing the radar  
8 shielding particles, the particles can be made to expand or  
9 contract by controlling the over all film temperature. This  
10 minute expansion, and/or contraction with temperature change can  
11 effectively lengthen or shorten the dipole particles and thus can  
12 be "tuned" for a specific impinging signal. The size change of  
13 the temperature controlled particles in most case need only be  
14 very minute, perhaps on the order of nanometers, to achieve this  
15 effect.

16 Thermochromic materials are widely used and well-known. For  
17 example they are frequently used on oral thermometers. These  
18 materials may be incorporated in a paint layer, or they  
19 themselves used as a paint layer. The specific product used will  
20 be selected for its color at specific temperatures.

21 As a single example, Tomn Industries, Inc., North Hollywood,  
22 California 91436 product # MC-8 is colored black at about below  
23 100 degrees, and colored clear at about above 100 degrees.

24 Various of these products can be mixed to achieve effects at

1 different temperatures.

2 This invention is adaptable to respond to commands from its  
3 own proprietors, or to incoming signals, and is responsive and  
4 adaptive over a wide spectrum range. This frequency range  
5 extends from infrared through color to very high frequencies.

6 For example, if the user is concerned about the IR emission  
7 he may change it by program or switching systems actuated by him.  
8 Alternatively, sensing an incoming heat seeking missile can cause  
9 a response in the system to change the temperature of the  
10 surface.

11 Similar arrangements are useful for color control and color  
12 change.

13 As to radar frequencies, the system can be arranged so that  
14 the perceived surface reflects or absorbs as desired. It  
15 requires only small dimensional changes in the surface contents  
16 to make a surprisingly large difference in radar reflection or  
17 absorption.

18 Such a broad range of adaptability is unknown at the present  
19 time.

20 This invention is not to be limited by the embodiments shown  
21 in the drawings and described in the description, which are given  
22 by way of example and not of limitation, but only in accordance  
23 with the scope of the appended claims.